An Analysis of Acquisition Cost, Performance, and Schedule Characteristics for DoD Programs

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1.0 Introduction

In an article that appeared in the Acquisition Research Quarterly Spring 2003 Special Issue on Risk Management, Coleman, et. al. discussed relationships between cost growth and schedule growth and cost and schedule length [1]. The research used a 1993 RAND database of Selected Acquisition Reports (SARs) for the analysis. Coleman, et. al. performed a statistical analysis on the above data, and found in part that there was no significant correlation between cost growth and schedule growth and cost and schedule length.

While the Coleman et. al., analysis contains some interesting results, it is limited in that there is no discussion of the performance dimension, technical constraints and other considerations (e.g., buyer and seller objectives and utility functions).

2.0 Conrow Analysis of DoD Program Cost, Performance, and Schedule Characteristics

In 1985-1995, Conrow (with the assistance of Arthur Alexander and Giles K. Smith) developed an analytical framework for relating buyer (e.g., government) and seller (e.g., prime contractor) preferences and interactions [2], [3]. [Portions of these analyses are also contained in reference 4.] This analytical framework in part modeled the buyer and seller preferences as objective functions of the form:

$$U(i) = f(C, P, S) \quad (1)$$

where:
U = utility of the i^{th} party (e.g., buyer, seller)
C = cost
P = performance
S = schedule

To validate this framework, Conrow (with the assistance of RAND and OSD personnel) during 1988-1995 collected and analyzed a SAR database composed of major development programs that were non follow-on programs, with data associated with the Engineering and Manufacturing Development (EMD) (or equivalent) program phase. The database included 48 programs (cost), 52 programs (performance), and 51 programs (schedule); and was primarily composed of aircraft and missile programs (about 80%), with the remainder representing a variety of different DoD

program types. All programs included in the database achieved initial operational capability (IOC), and had EMD (or equivalent) start dates during the 1950s through 1980s. Although a number of comparisons of various relationships between cost, performance, and schedule (C,P,S) were made, and between these relationships and change data, the results reported here involve changes in cost, performance, and schedule from the beginning of EMD (or equivalent) to IOC. [Note: the analytical framework and full results associated with this statistical analysis remain an unpublished manuscript and are an input for a book to be authored by Conrow in the future.]

The analytical framework predicted in part that due to differences in the buyer and seller objective functions, coupled with technical constraints associated with C,P,S, cost and/or schedule would be adjusted in order to meet performance requirements during the development phase of many DoD, NASA, and some other government programs. The statistical analysis of the SAR data validated five primary (and one secondary) hypotheses proposed by Conrow.

First, the average and median change results from the start of EMD to IOC should be larger for cost change and schedule change than for performance change. The statistical analysis estimated results for cost change (1.26 and 1.16), performance change (1.00 and 1.00), and schedule change (1.24 and 1.13), and that the results for cost change and schedule change were larger than those for performance change. (For example, for cost change, there was on average a 26% increase in cost from the start of EMD to IOC.) *Note also that both the average and median performance change were 1.00.* Second, the standard deviation of performance change should be smaller than that for cost change and schedule change. The statistical analysis revealed that the standard deviation for performance change was less than 1/2 that for cost change and schedule change. Third, most programs should exhibit cost change and/or schedule change > 1.0 (indicating cost growth and/or schedule slippage.) The statistical analysis revealed that the vast majority of programs exhibited cost growth (90%) and schedule slippage (78%). Fourth, the skewness associated with performance change should be smaller than for cost change and schedule change. The statistical analysis revealed that the skewness for performance change was very small (0.38), while that for cost change (1.24) and schedule change (1.24) was noticeably larger. Fifth, there should be negligible correlation between C,P,S change and the EMD start date. The statistical analysis revealed very low correlation between the EMD start date and C,P,S change. (A secondary hypothesis was that there should be negligible correlation between cost change, performance change, and schedule change. The statistical analysis revealed that the correlation coefficients very low--effectively uncorrelated.)

The six observations mentioned above are consistent with predictions from the analytical framework associated with buyer/seller objective functions, utility preferences, and technical constraints. The results validate the hypotheses that in DoD acquisition (as least with EMD start dates from the 1950s to 1980s, performance was the dominant variable, and achieving performance requirements was the primary buyer/seller goal of the three variables. Because cost change and schedule change are not generally as tightly constrained at the program level as performance change, and because a primary goal of both the buyer and seller in DoD development programs is to meet performance requirements, the resulting behavior at the program level is that cost and/or schedule are adjusted in order to meet performance requirements on a program-by-program basis. (Since the observations are at the total program

level (WBS 1.0), they represent an aggregation of lower WBS-level results. These lower WBS-level results are generally not documented and may in part be different than those observed at the total program level.)

3.0 Discussion

Including buyer/seller objective functions and utility preferences associated with C,P,S points to inherent instabilities in the resulting outcomes, and given appropriate technical constraints, the resulting behavior discussed above [2], [3]. Only examining some aspects of cost and/or schedule, and without buyer/seller objective functions, utility preferences, and technical constraints (as in reference. [1]), provides at best a limited evaluation of acquisition dynamics yet masks other potential insights associated with the acquisition process.

Similarly, acquisition strategies such as Cost As an Independent Variable (CAIV) are potentially limited because they focus primarily on the cost:performance dimensions. As discussed above, and from eq. (1) the true trade space is U = f (C,P,S) and when properly represented this corresponds to cost, performance, schedule, and risk. *Thus, three variable pairs must be considered and evaluated* ***simultaneously****, along with appropriate preferences and technical constraints, not just one variable pair which is done* ***independently****.* Again, this is because the trade space is cost, performance, schedule, and risk, and risk includes cost, performance, and schedule dimensions as well. Hence, risk management processes that focus, for example, on cost and schedule, and do not include the technical/performance dimension, are also lacking since only two of the three relevant risk dimensions are examined.

4.0 References

[1] Richard L. Coleman, Jessica R. Summerville, and Megan E. Dameron, "The Relationship Between Cost Growth and Schedule Growth," *Acquisition Review Quarterly*, Vol. 10, No. 2, Spring 2003, pp. 117-122.

[2] Edmund H. Conrow, "Some Long-Term Issues and Impediments Affecting Military Systems Acquisition Reform," *Acquisition Review Quarterly*, Vol. 2, No. 3, Summer 1995, pp. 199-212. A slightly different version of this paper ("Some Long-Term Issues and Impediments Affecting Systems Acquisition Reform") was presented at the 1995 Defense Systems Management College Acquisition Research Symposium and chosen for the David D. Acker Award for Skill in Communication (co-winner of the best paper of the symposium).

[3] Edmund H. Conrow, "Some Characteristics for Design Selection in Commercial, Government, and Defense Programs," Acquisition Research Symposium Proceedings, Defense Systems Management College, Ft. Belvoir, VA, June 1997, pp. 195-217.

[4] Edmund H. Conrow, *Effective Risk Management: Some Keys to Success*, Second Edition, American Institute of Aeronautics and Astronautics, 2003, Chapter 1, Appendix C, Appendix D.

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5.0 Vita

Dr. Edmund H. Conrow is a risk management consultant to government and industry with 20+ years experience; on hardware-intensive, software-intensive, and mixed projects, with life cycle dollar ranges from several million dollars to many billion dollars. He is credited with helping to develop much of DoD's best practices on risk management, and has served as a risk manager and mentor to risk managers on a number of programs. Dr. Conrow is an Associate Fellow of AIAA, Senior Member of IEEE, Certified Management Consultant (Institute of Management Consultants), Certified Professional Consultant to Management (National Bureau of Certified Consultants), and a Project Management Professional (Project Management Institute). He is the author of "Effective Risk Management: Some Keys to Success," Second Edition, AIAA (2003) and is widely published in journals and conferences. He holds a BSNE and MS in nuclear engineering, M. Phil. in policy analysis, Ph.D. in general engineering and Ph.D. in policy analysis.